A state-of the-art survey & testbed of fuzzy AHP (FAHP) applications

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ABSTRACT

As a practical popular methodology for dealing with fuzziness and uncertainty in Multiple Criteria Decision-Making (MCDM), Fuzzy AHP (FAHP) has been applied to a wide range of applications. As of the time of writing there is no state of the art survey of FAHP, we carry out a literature review of 190 application papers (i.e., applied research papers), published between 2004 and 2016, by classifying them on the basis of the area of application, the identified theme, the year of publication, and so forth. The identified themes and application areas have been chosen based upon the latest state-of-the-art survey of AHP conducted by [Vaidya, O., & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. European Journal of operational research, 169(1), 1–29.]. To help readers extract quick and meaningful information, the reviewed papers are summarized in various tabular formats and charts. Unlike previous literature surveys, results and findings are made available through an online (and free) testbed, which can serve as a ready reference for those who wish to apply, modify or extend FAHP in various applications areas. This online testbed makes also available one or more fuzzy pairwise comparison matrices (FPCMs) from all the reviewed papers (255 matrices in total).

In terms of results and findings, this survey shows that: (i) FAHP is used primarily in the Manufacturing, Industry and Government sectors; (ii) Asia is the torchbearer in this field, where FAHP is mostly applied in the theme areas of Selection and Evaluation; (iii) a significant amount of research papers (43% of the reviewed literature) combine FAHP with other tools, particularly with TOPSIS, QFD and ANP (AHP's variant); (iv) Chang's extent analysis method, which is used for FPCMs' weight derivation in FAHP, is still the most popular method in spite of a number of criticisms in recent years (considered in 57% of the reviewed literature).

1. Introduction

Multiple criteria decision-making (MCDM) methods are frequently used to solve real world problems with multiple, conflicting, and incommensurate criteria and/or objectives. Hwang and Yoon (1981) have classified the MCDM methods into two categories: multi-attribute decision-making (MADM) and multi-objective decision-making (MODM). MADM techniques, unlike MODM, heavily involves human participation and judgments. Research on human judgments and decision making shows that the human brain is able to consider only a limited amount of information at any one time (Simpson, 1996), which makes it unreliable to take decisions when facing complex problems. Analytic Hierarchy Process (AHP), initially introduced by Saaty (1980), is by now one of the most widely applied MADM techniques, whose main strength lies in its impartial and logical grading system (reducing personal biases and allowing for comparing dissimilar alternatives), but also in its flexibility to be integrated with various techniques like Linear Programming, Quality Function Deployment, Fuzzy Logic, *etc.* (Saaty & Vargas, 2001; Vaidya & Kumar, 2006). This enables users to extract benefits from all the combined methods and achieve the desired goal in a better way.

As a practical popular methodology for dealing with fuzziness and uncertainty, the Fuzzy Logic combined with AHP, more commonly known as Fuzzy AHP or FAHP (van Laarhoven & Pedrycz, 1983), has found huge applications in recent years. According to a recent survey on Fuzzy MCDM techniques (Mardani, Jusoh, & Zavadskas, 2015), FAHP is the second most widely used technique in a stand-alone mode (just after AHP). Since, as of this writing, no state-of-the-art survey of FAHP has been issued – *the latest survey being dedicated to AHP and dating back to 2006* (Vaidya & Kumar, 2006) – this article looks into the research papers with a view to understand the spread of FAHP in different fields. Based on a classification scheme, a reference repository has been established, including around 200 international journal papers (starting from 2004). Papers have been classified based on various dimension s, including the year of publication, application area, identified theme, authors' nationality, *etc.* This survey goes along with an online and free testbed[1] that makes the results and findings of this study available, as well as one or more fuzzy pairwise comparison matrices (FPCMs) from all reviewed papers. For the anecdote, the genesis of this state-of-the-art survey started from a personal motivation around the study and de-

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[1] http://fahptestbed.sntiotlab.lu/